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Relative abundance and percent bottom cover of benthic lifeforms in the marine protected area of barangay poblacion, Kauswagan Lanao del Norte, Philippines

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Abstract

This study was conducted to establish baseline informations on the relative abundance and the percent bottom cover of existing lifeforms of scleractinian corals in the Marine Protected Area of sitio Kauswagan, Brgy. Poblacion, Lanao del Norte., Philippines. The coral reef was assessed using digital photo-transect technique. *Acropora* lifeforms include branching with relative abundance (RA) of 20%, submassive 10% and digitate 70%. *Montipora digitata* (Acroporidae) was the most abundant digitate coral in the MPA. Non-*Acropora* lifeforms include branching with abundance of 38.7%, submassive 24.3%, massive 23.7%, encrusting 6.13%, foliose 0.8%, *Millepora* 0.8%, mushroom 5.33% and *Heliopora* 0.27%. The RA of branching lifeforms are 20% and 38.7% in *Acropora* and Non-*Acropora* categories respectively while RA of non-branching massive and submassive lifeforms are higher and account for 80% and 41.33% in *Acropora* and non-*Acropora* categories respectively. Massive and submassive lifeforms are slow growing, however they withstand strong wave action during storms. The low RA of algae associated with dead corals of 4.79% maybe due to the grazing activities of herbivorous fishes in the reef. Sponges, the most abundant fauna can possibly limit growth and cause death to corals due to poor nutrient and oxygen supply secondary to obstructed water flow and limited sunlight to the coral colony. The high abundance of dead coral and rubble indicated that the reef was exposed to man-made damaging threats as well as to the effects of natural calamities. Non-Acropora lifeforms constitute the highest percentage bottom cover of 32.7%. This is followed by dead corals 22.11% and abiotic lifeforms 13.51%. *Acropora* has a significantly low bottom cover of 17.21%.

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Introduction

Coral reefs are known as tropical marine ecosystems with high productivity, which has important role not only on biodiversity including genetic but also on fisheries productivity (Munasik *et al.*, 2011, Ackiss *et al.*, 2013). Coral reefs provide shoreline protection services as a first line of defense from erosion through wave attenuation and the production of sediment (Elliff *et al.*, 2017). The reef crests of fringing reefs can act as breakwaters by dissipating wave energy (Gallop *et al.*, 2014, Rogers *et al.*, 2016) and meta-analysis reveal that coral reefs can provide substantial protection by reducing on average 97% of the wave energy (Ferrario *et al.*, 2014). However, coral reefs are fragile ecosystems and susceptible to various natural and artificial disturbances such as global warming, strong storms, overfishing, marine pollution, and other destructive practices (Burke *et al.*, 2011, Bellwood *et al.*, 2004). Intense fishing pressure especially the use of destructive fishing methods such as the use of explosives and drive nets on coral reef rapidly deteriorate the abundance and richness of corals, fishing then was considered to be one of the major causes of coral destruction (Piquero *et al.*, 2013).

Marine Protected Areas (MPAs) are marine areas in which human activities are restricted (Gallacher *et al.*, 2016), in order to protect and manage marine and coastal resources against threats of overexploitation and ecological damage (Cleguer *et al.*, 2015). The purpose of MPAs is ecological, to preserve the ecosystem but almost all measurements of the success of MPA use social and economic measures, either exclusively or together with ecological (Yates *et al.*, 2019). Implementation of Marine Protected Area or no-take-zone was introduced as a tool to manage fisheries and conserve corals (Piquero *et al.*, 2013). This study aims to characterize the community structure of corals in the Marine Protected Area in sitio Kauswagan, Brgy. Poblacion, Lanao del Norte., Philippines. Specific objectives of the study include: 1) identification of the different lifeforms of scleractinian corals, (2) estimation of the relative abundance of the various lifeforms, and 3) estimation of the percent cover of the existing lifeforms of corals in the area.

Materials and methods

Description of the study area

The study area is located in the MPA of barangay Poblacion, municipality of Kauswagan, province of Lanao del Norte, Philippines. Kauswagan is the second coastal municipality of the province of Lanao del Norte located near the southern boundary. It lies on the mid-central portion of the Northwestern Mindanao coastline and is located 20 kilometers away from Iligan City. (Fig. 1). The MPA has coordinates 8°12'7" North and 124° 6'5" East with an estimated area of 29 hectares. The reef is found at a depth of between 6-8 meters with generally flat terrain iterspersed with coral mounds of approximately one meter high.

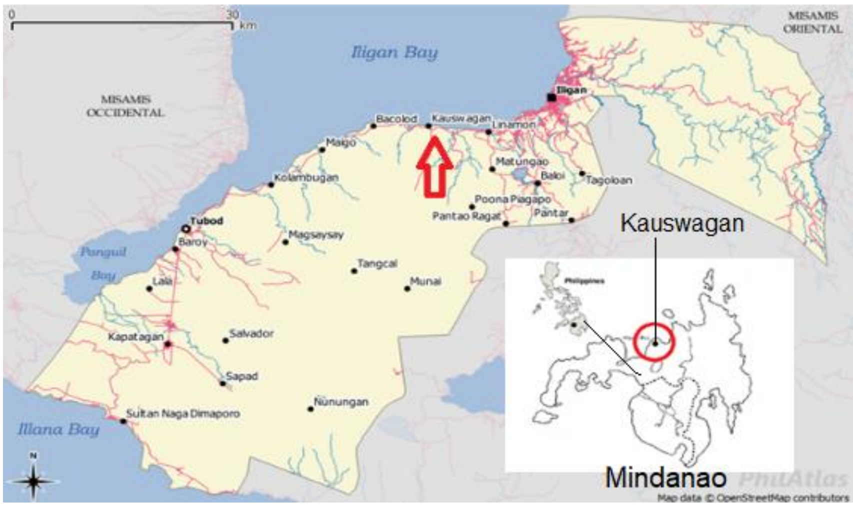

Fig. 1. Map of the sampling area in Iligan Bay indicated by the red arrow. Inset map shows the location of the study site in Mindanao (PhilAtlas).

Assessment of the coral reef

The coral reef was assessed using digital photo-transect technique, a modification of the video-transect technique described by Osborne and Oxley (1997). The method involved the use of a digital still camera attached to a modified aluminum distance bar the length of which was pre-adjusted so that the area of the substrate covered by the image was 1m². Photographs of the substratum were taken every meter starting at 0 m to 150 m to come up with 151 photoquadrats for the 150 meter transect line (Fig. 2).

Fig. 2. Digital Phototransect sampling method for assessment of coral lifeforms and coral associates (Source: Tools and Techniques in Monitoring Coral Reefs) (Left); A photoquadrat taken at transect depth of 6-8m with the 5 subsamples represented by circles (Right).

The *frequency of occurrence* of a lifeform category is the number of times the lifeform occurred in all the 755 subsamples in 151 photoquadrats with 5 subsamples per photoquadrat.

The *relative abundance (RA)* of a lifeform is equal to the frequency of a lifeform divided by the total frequency of all lifeforms in one particular category multiplied by 100. The *percentage bottom cover (PBC)* of a lifeform is equal to the sum of all the points of a lifeform in all the 151 photoquadrats divided by the sum of all points of all lifeforms in all categories multiplied by 100.

Results and discussion

Relative abundance (RA) of lifeforms

In *Acropora* category, digitate, branching and massive were the existing *Acropora* lifeforms in the study area (Fig.3). Branching lifeform (ACB) was represented by *Acropora tenuis* and *Acropora millepora* 20%, submassive lifeform (ACS) *by Astreopora sp*. 10% while digitate lifeform (ACD) was represented by *Montipora digitata* with RA of 70%. *M. digitata*., the most abundant digitate coral in the study area is classified under Family Acroporidae. It is characterized by broad cylindrical, anastomosing upright branches with tapered ends, hence less prone to fragmentation caused by strong waves. With digitate and arborescent growth forms, this species tend to have high cover in extreme tidal condition and often confronts with severe bleaching, cyclone, freshwater run-off, sedimentation, wave action and competition. The habitat of this species is often categorized as marginal reefs (Harpeni *et al.*, 2011). Listed as one of the fast growing species of corals, the populations of *M. digitata* have a relatively short period of growth and mass reproduction before they die and had the strong power of regeneration (Heyward *et al.*, 1985; Heyward *et al.*, 2011).

In non-*Acropora* category, the existing dominant lifeforms were branching (CB) 38.7%, submassive (CS) 24.3%, massive (CM) 23.7%. Other existing lifeforms include encrusting, digitate, foliose, *Millepora*, mushroom and *Heliopora* (Fig. 3). The least abundant is *Heliopora* (CHM) with RA of 0.03%. The RA of branching lifeforms was 20% and 38.7% in *Acropora* and non-*Acropora* categories respectively while the RA of non-branching massive and submassive lifeforms are higher and account for 80% and 41.33% in *Acropora* and Non- *Acropora* categories respectively. Branching corals grow up to 10 cm per year (Shinn, 1966).

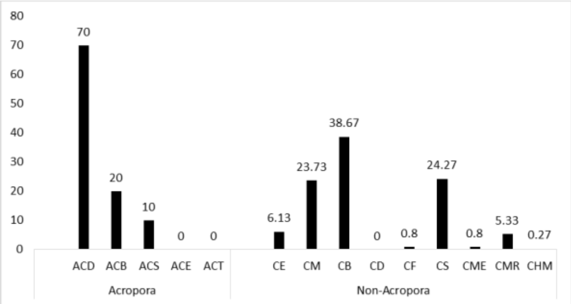

Fig. 3. Relative abundance of scleractinian coral lifeforms in *Acropora* and Non-*Acropora* categories in Poblacion, Kauswagan reef.
ACD- Acropora Digitate; ACB- Acropora Branching; ACS- Acropora Submassive; ACE- Acropora Encrusting; ACT- Acropora Tabular; CE- Non-Acropora (NA) Encrusting; CM- NA Massive; CB-NA Branching; CD- NA Digitate; CF- NA Foliose; CS- NA Submassive; CME- Millepora; CMR- Mushroom; CHM- Heliopora

The linear growth rate of *Acropora formosa* and *Acropora nobilis* in appropriate water temperature is 1.19 ± 0.08 and 1.14 ± 0.11 cm/month respectively (Saptarini *et al.*, 2017). In contrast, massive corals have slower growth rates with massive *Porites spp.* 10–15mm/yr (Lough *et al.*, 1999); *Porites astreoides* 3-5mm/y (Elizalde-Rendon *et al.*, 2010); *Montastrea sp.* 8-10mm/yr (Carricart-Ganivet, 2004); massive *Diploastrea heliopora* 2-6mm/yr (Bagnato *et al.*, 2004; Damassa *et al.*, 2006; Cantin *et al.*, 2010). The higher abundance of non-branching, especially massive and submassive forms over the branching lifeforms is mainly due to its capability to withstand mechanical stresses in its environment. Massive and submassive lifeforms are slow growing, however they withstand strong wave action during storms (Piquero *et al.*, 2013).

Macroalgae, was represented by *Turbinaria conoides,Actinotricha fragilis.,* and *Chlorodesmis fastigiata,* brown, red and green macroalgae respectively. The low RA of macroalgae associated with dead corals (DCA) of 4.79% (Fig.5) and percentage bottom cover of 1.06% (Fig. 6) maybe due to the grazing activities of observed herbivorous fishes in the reef. Herbivory is often likely to be much more important than nutrients in limiting algal growth (Miller *et al.*, 1999).

For other fauna category (OT), sponges were the most abundant with a very high RA of 93.55%. The remaining 6.45% was represented by occasionally observed soft corals, starfishes and ascidians. Encrusting sponges were generally thin and soft, others leathery and form elaborate mats on surfaces of corals. Hard and thick, branching sponges were found firmly attached and entangled among the branches of corals. Other species spread massively and totally covered the whole branching coral colony (Fig. 4). Ocular observations during repeated dives in the area suggested that sponges can limit growth and cause death to corals due to poor nutrient and oxygen supply secondary to obstructed water flow and limited sunlight to the coral colony. Dead, broken coral branches observed in the area may have resulted from mechanical stresses as well as fragmentation when these sponges grow, enlarge and exert pressure among coral branches. Massive growth of encrusting sponges prevent recruitment of coral planulae on surfaces of dead corals.

On dead coral category, dead coral (DC) has a higher RA of 92.21% relative to dead coral with algae (DCA) with an RA of only 4.8% (Fig. 5).

Within the abiotic lifeforms category, rubble (R) has the highest RA of 77.45% followed by sand (S) with 22.55% (Fig.5). The very high cover of dead coral (DC) of 92.21% complemented by equally high cover of rubble 77.45% (Fig. 5) indicated that the MPA biodiversity had been completely neglected over the years and was exposed to man-made damaging threats which may include illegal fishing practices, overfishing, pollution, mining in the uplands, as well as to the effects of natural calamities. Giant waves of Tropical storm, Pablo in October 25, 2019 excavated and overturned large areas of coral reefs from deeper waters and dragged them to shallower coastal areas.

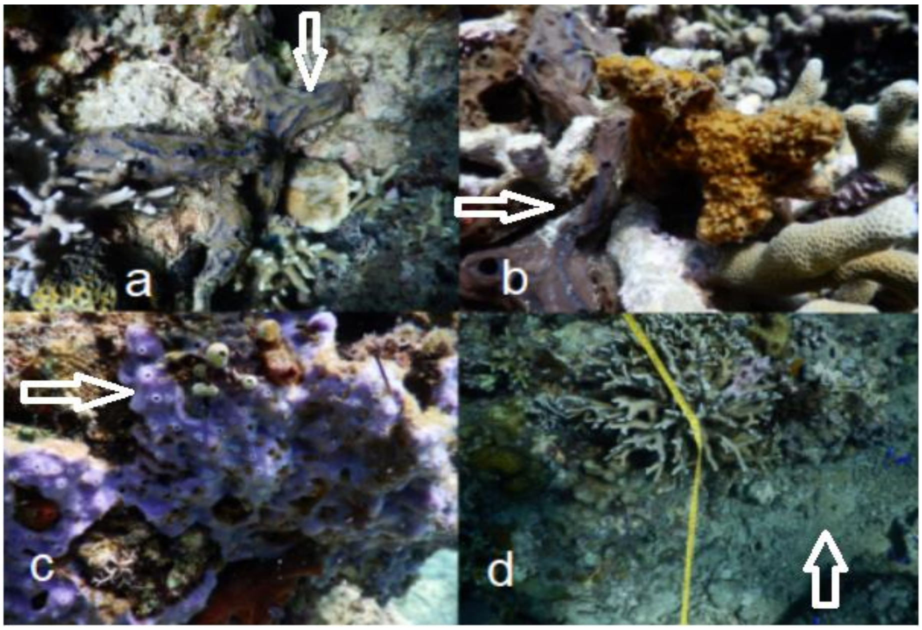

Fig. 4. Sponges closely associated with corals. a-b Thick,branching sponges; c-d Encrusting sponges.

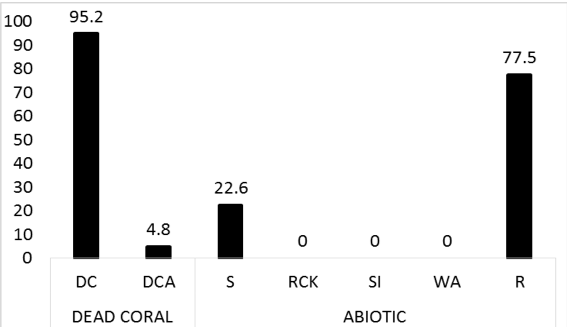

Fig. 5. Percent relative abundance of dead corals and abiotics categories.

DC -Dead coral; DCA- Dead coral with algae; S-Sand; RCK-Rock; SI- Silt; WA - Water; R - Rubble.

Percent bottom cover (PBC) of lifeforms

Non-*Acropor*a lifeforms distributed among 22 coral species has the highest PBC of 32.7% (Fair) (Fig.6). This is followed by dead corals 22.11% (Poor), abiotic 13.51% (Poor), other fauna 12.32% (Poor) and algae 1.06% (Poor). *Acropora* lifeforms represented a "poor" PBC of 17.21% (Fig. 7). Ideally, *Acropora* species are more likely to dominate at a location with a supporting water conditions because they have higher growth rates compared to other species. Branching *Acropora* is able to grow rapidly with a growth rate of 5-20 cm/yr, inversely proportional to *Porites* massive lifeform whose radial growth rate is only 1- 2cm/yr (Toda *et al*., 2007). However, findings of this study showed that *Acropora,* represented only by branching, digitate and submassive lifeforms, had a total PBC of only 17.21%. Species of branching *Acropora* are fragile species and they are susceptible to physical disturbances caused by storms resulting in large numbers of broken branches and toppled colonies especially in high wave activity (Lirman, 2000, Tunnicliffe, 1981). Branching and digitate lifeforms were fast growing but they are sensitive to strong waves, hence easily fragmented (Piquero *et al*., 2013). Lanao del Norte was heavily devastated by typhoon Ondoy in 2009, Sendong in 2011, and by the strongest tropical cyclone Pablo in 2012. In addition to natural calamities, massive growth of sponges may have caused fragmentation and demise of branching corals. Extensive growth of sponges completely cover coral colonies and these growth patterns may have caused suffocation and massive death of *Acropora* colonies in the study area. Non-*Acropora* consisted of *Pocillopora* species which have shorter, robust and more resistant branches to mechanical stress.

In addition to *Pocillopora,* massive and submassive lifeforms of *Porites, Favites, Favia, Galaxea, Montastrea, Goniastrea, Pachyseris Goniopora, Diploastrea, Platygyra and Leptoria* make up the total PBC of non-*Acropora* lifeforms to 32.7%. Toda *et al.* (2007) cited that although massive lifeforms have slower growth rates, the occurrence of resistant species against environmental stresses like massive *Porites* is directly proportional to the level of diversity in the area, the higher its existence the higher the diversity in the area. In general, the PBC of most lifeforms, except for non-*Acropora,* had "poor status" based on criteria of Mada *et al.* (2017). As previously explained, the MPA had been completely neglected over the years and was exposed to man-made damaging threats as well as to the effects of natural calamities.

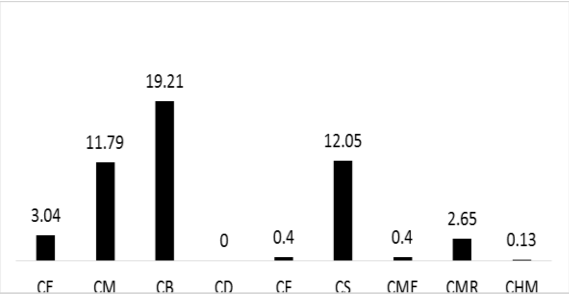

Fig. 6. Distribution of percent coral cover among non-*Acropora* lifeforms.
CE- Non-Acropora (NA) Encrusting; CM- NA Massive; CB-NA Branching; CD- NA Digitate; CF- NA Foliose; CS- NA Submassive; CME- Millepora; CMR- Mushroom; CHM- Heliopora

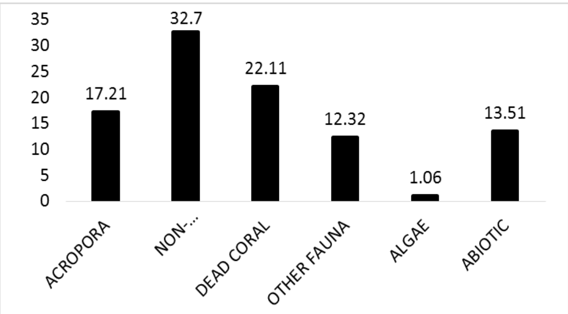

Fig. 7. Percentage bottom cover (PBC) of major lifeform categories in the reef. Poor : 0-24.9%; Fair : 25-49.9%; Good: 50-74.9%; Excellent: 75-100% (Mada *et al*., 2017).

Conclusion

Branching, digitate and submassive lifeforms were the only lifeforms of *Acropora* recorded. In Non-*Acropora*, the existing dominant lifeforms were branching, submassive, massive lifeforms and six other lifeforms distributed among 22 species of corals with higher relative abundance of non-branching, massive and submassive lifeforms.

Massive and submassive lifeforms are slow growing, however they withstand strong wave action during storms.The low relative abundance and cover of macroalgae associated with dead corals maybe caused by the grazing activities of herbivorous fishes in the coral reef. The massive proliferation of sponges can possibly cause poor water circulation, inhibit growth and cause death to many corals due to less light available, poor nutrient and oxygen supply to the corals. Dead corals may have resulted from natural calamities, man-made threats and fragmentation when branching sponges grow and enlarge among coral branches. Non- *Acropora* lifeforms recorded the highest bottom cover with more resistant branching and massive lifeforms. This is followed by dead corals and abiotic lifeforms. The total PBC of lifeforms with Acropora and Non-Acropora categories combined is 49.91% which is classified under "good" status.

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